PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference KOHEPA0302WO	**FOR FURTHER ACTION**	See Form PCT/IPEA/416
International application No. PCT/EP2004/053653	International filing date *(day/month/year)* 22.12.2004	Priority date *(day/month/year)* 22.12.2003
International Patent Classification (IPC) or national classification and IPC G02F1/365		
Applicant KOHERAS A/S et al		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 6 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *sent to the applicant and to the International Bureau)* a total of 3 sheets, as follows:
      ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).

4. This report contains indications relating to the following items:

☒	Box No. I	Basis of the opinion
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application

Date of submission of the demand	Date of completion of this report
23.09.2005	01.03.2006
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer Lüssem, G Telephone No. +49 89 2399-2085

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/EP2004/053653

Box No. I Basis of the report

1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

   ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
   - ☐ international search (under Rules 12.3 and 23.1(b))
   - ☐ publication of the international application (under Rule 12.4)
   - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages	
1-19	as originally filed
Claims, Numbers	
1-16	filed with telefax on 14.02.2006
Drawings, Sheets	
1/7-7/7	as originally filed

   ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☒ The amendments have resulted in the cancellation of:
   - ☐ the description, pages
   - ☒ the claims, Nos. 1-20
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
   - ☐ the description, pages
   - ☐ the claims, Nos.
   - ☐ the drawings, sheets/figs
   - ☐ the sequence listing *(specify)*:
   - ☐ any table(s) related to sequence listing *(specify)*:

* *If item 4 applies, some or all of these sheets may be marked "superseded."*

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-20
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-20
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-20
	No:	Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Re Item V.

Reasoned statement with regard to novelty and inventive step; citations and explanations supporting such statement

1. Reference is made to the following document:

D1: DATABASE INSPEC [Online] THE INSTITUTION OF ELECTRICAL ENGINEERS, STEVENAGE, GB; September 2003 (2003-09), TOWN G E ET AL: "Optical supercontinuum generation from nanosecond pump pulses in an irregularly microstructured air-silica optical fiber" XP002326599 Database accession no. 7855768.

2. INDEPENDENT CLAIM 1

2.1 The document D1 is regarded as being the closest prior art to the subject-matter of claim 1, and shows (the references in parentheses applying to this document):

A source of light of a spectrum of wavelengths extending over more than 300nm (see figures 2 and 3)

comprising

- a laser (Nd:YAG) which operates at its fundamental wavelength in the range [1000-1100]nm (namely: 1064nm) and produces pulses of a duration longer than 0.5ns (namely: 42ns)

and

- a micro-structured optical fibre arranged to guide the pulses

wherein the light is generated by the pulses in the fibre.

2.2 The subject-matter of claim 1 differs from this known source of light in that

(i) the fibre has a core with a diameter greater than 4µm;

(ii) the fibre has a zero dispersion wavelength between [1000-1100]nm;

(iii) the fibre is arranged to support propagation of the light in a single transverse mode at all wavelengths in the spectrum of wavelengths;

(iv) the laser is a monolithic laser.

2.3 The subject-matter of claim 1 is therefore new (Article 33(2) PCT).

2.4 The problem to be solved by the present invention may be regarded as how to provide a broad single-mode spectrum light source enabling a higher output power of the supercontinuum spectrum compared to the source of D1 while having a more compact design.

2.5 The solution to this problem proposed in claim 1 of the present application is considered as involving an inventive step (Article 33(3) PCT) for the following reasons:
Although the skilled person would - without using inventive activity - introduce distinguishing features (iii) (e.g. by exchanging the random type fibre of D1 with a solid core photonic crystal fibre having hexagonal symmetry) and (iv) when trying to solve the sub-problems of how to provide a single-mode spectrum and an overall compact design, he would not be led straightforwardly to introduce features (i) or (ii) or even both concomitantly. This is because firstly, with regard to feature (i), the skilled person would try to keep the core size as small as possible - instead of using a relative large size of 4µm or even more - in order to promote non-linear effects in the fibre. Secondly, to set the zero dispersion wavelength of the fibre close to the pump wavelength (feature (ii)) in order to increase the non-linear efficiency is not indicated in D1 or suggested in any other document at hand for the ns-regime pump pulses used in the device.

3. INDEPENDENT CLAIM 16

3.1 As a consequence of the of what has been set out under point 2 above with regard to the device of claim 1, it follows that also claim 16 meets the requirements of the PCT with respect to novelty and inventive step, because the subject-matter defined therein relates to a process for generating light by providing, arranging and using each component of the device of claim 1.

4. DEPENDENT CLAIMS 2-15

4.1 Claims 2-15 are dependent on claim 1 and as such also meet the requirements of the PCT with respect to novelty and inventive step.

CERTAIN REMARKS (regarding defects noted in the present application):

5.1 The independent claims have not been written in the two-part form (as would be required by Rule 6.3(b) PCT).

5.2 The features of the claims have not been provided with reference signs placed in parentheses (as would be required by Rule 6.2(b) PCT).

5.3 The unit "microns" employed in claims 1, 13 and 16 and in the description (e.g. on p.6, l.5) has not been additionally expressed in terms of the unit stipulated by Rule 10.1(a) PCT.

5.4 The term "pitch" as used in claim 14 is ambiguous, as it could also refer to the pitch of

the fibre in the conventional sense (imaging properties of GRIN fibres). It is recommended to use the term "hole-to-hole pitch" instead in the claim.

5.5 The order and the assignment of the spectra of figures 4 and 5 appear to have been confused.

5.6 From figure 8 it is not clear which curve represents data for fibre O and which one represents data for fibre P.

5.7 Caption of figure 7 refers to "colour".

A BROAD SPECTRUM LIGHT SOURCE

CLAIMS

1. A source of light of a spectrum of wavelengths extending over more than 300 nm, comprising a laser, which operates at or near its fundamental wavelength in the range 1000 nm to 1100 nm and produces pulses of a duration longer than 0.5 ns, and a micro-structured optical fibre arranged to guide the pulses, wherein the light is generated by the pulses in the fibre, and in which the micro-structured optical fibre has a core having a diameter greater than 4 microns and a zero dispersion wavelength between 1000 nm and 1100 nm, and is arranged to support propagation of the light in a single transverse mode at all wavelengths in the spectrum of wavelengths, and in which the laser is a monolithic laser.

2. A source as claimed in claim 1, in which the monolithic laser is a microchip laser.

3. A source as claimed in any preceding claim, in which the pulses of light are of a duration of more than 1 ns, such as more than 2 ns, such as more than 3 ns, such as more than 4 ns, such as more than 5 ns, such as more than 8 ns, such as more than 10 ns.

4. A source as claimed in any preceding claim, in which the pulses have a peak power of less than 50 kW, such as less than 20 kW, such as less than 15 kW, such as less than 10 kW, such as less than 9 kW, such as less than 3 kW, such as less than 1 kW.

5. A source as claimed in any preceding claim, in which the pulses have a peak power and interact with the fibre over a length of the fibre such that the peak power times the interaction length is less than 2 kWm, such as less than 1 kWm, such as less than 500 Wm.

6. A source as claimed in any preceding claim, in which the spectrum extends over more than 500 nm, such as over more than 700 nm.

7. A source as claimed in any preceding claim, in which the fundamental wavelength is longer than 600 nm.

8. A source as claimed in any preceding claim, in which the micro-structured optical fibre has a zero dispersion wavelength λ_0 and the operating wavelength of the laser is less than the zero dispersion wavelength.

9. A source as claimed in any of claims 1 to 7, in which the micro-structured optical fibre has a zero dispersion wavelength λ_0 and the operating wavelength of the laser is greater than the zero dispersion wavelength.

10. A source as claimed in any preceding claim, in which the micro-structured optical fibre is arranged to support propagation of the pulses in a single transverse mode.

11. A source as claimed in any preceding claim, in which the micro-structured optical fibre is arranged to support propagation of light at all wavelengths in a single transverse mode.

12. A source as claimed in any preceding claim, in which the micro-structured fibre has a pitch greater than 2.5 microns, such as greater than 2.7 microns, such as greater than 2.9 microns.

13. A source as claimed in any preceding claim, in which the micro-structured fibre has a core having a diameter greater than 4.5 microns, such as greater than 4.8 microns.

14. A source as claimed in any preceding claim, in which the micro-structured fibre has a cladding region comprising an array of holes of diameter d and pitch Λ, in which d/Λ is less than 0.7, such as less than 0.6, such as less than 0.5, such as less than 0.4.

15. A source as claimed in any preceding claim, in which the micro-structured fibre has an effective nonlinear area greater than 8 μm^2, such as greater than 9 μm^2, such as greater than 12 μm^2, such as greater than 14 μm^2, such as greater than 15 μm^2.

16. A method of generating light of a spectrum of wavelengths extending over 300 nm, comprising operating a monolithic laser at or near its fundamental wavelength in the range 1000 nm to 1100 nm to provide pulses of light of a duration longer than 0.5 ns and guiding the pulses in a micro-structured optical fibre, and in which the micro-structured optical fibre is arranged to have a core with a diameter greater than 4 microns and a zero dispersion wavelength between 1000 nm and 1100 nm, and to support propagation of the light in a single transverse mode at all wavelengths in the spectrum of wavelengths.